Experimental analysis of the impact of room/system design on night ventilation performance

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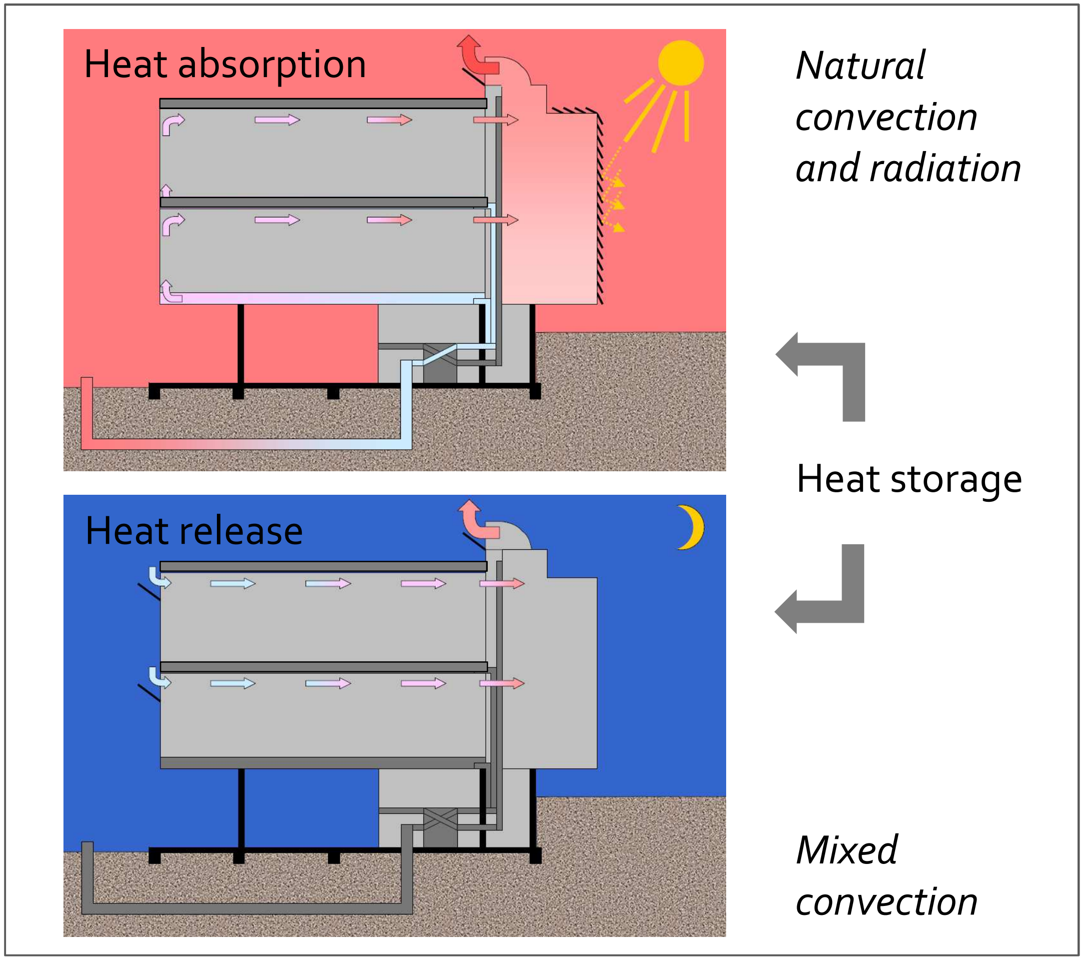
Convective heat transfer modelling is important during night cooling

Limited number of experiments on convective heat transfer in rooms under mixed convection conditions



Assess influence of indoor airflow pattern on mixed convection heat transfer

Experimental analysis in modified PASLINK cell

Two typical mixed convection cooling regimes

Measurement of air temperature/velocity and heat fluxes

Thorough uncertainty/sensitivity analyses

Useful for future CFD studies

Experimental data can act as a reference

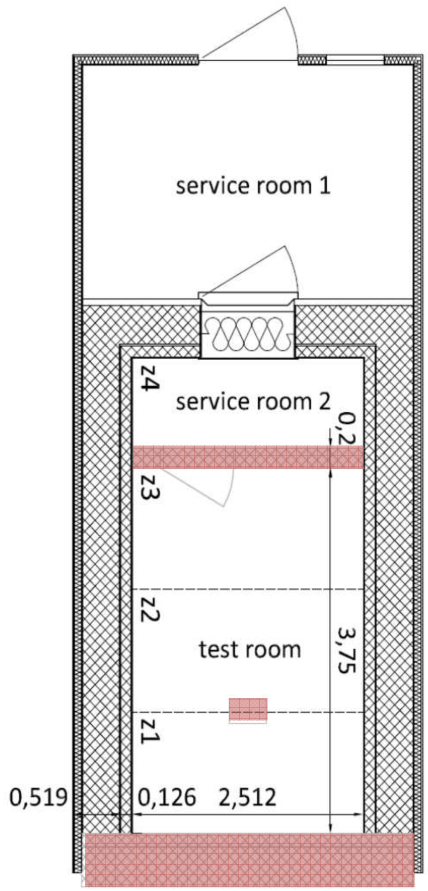
BBRI (Limelette, Belgium)

Test room setup

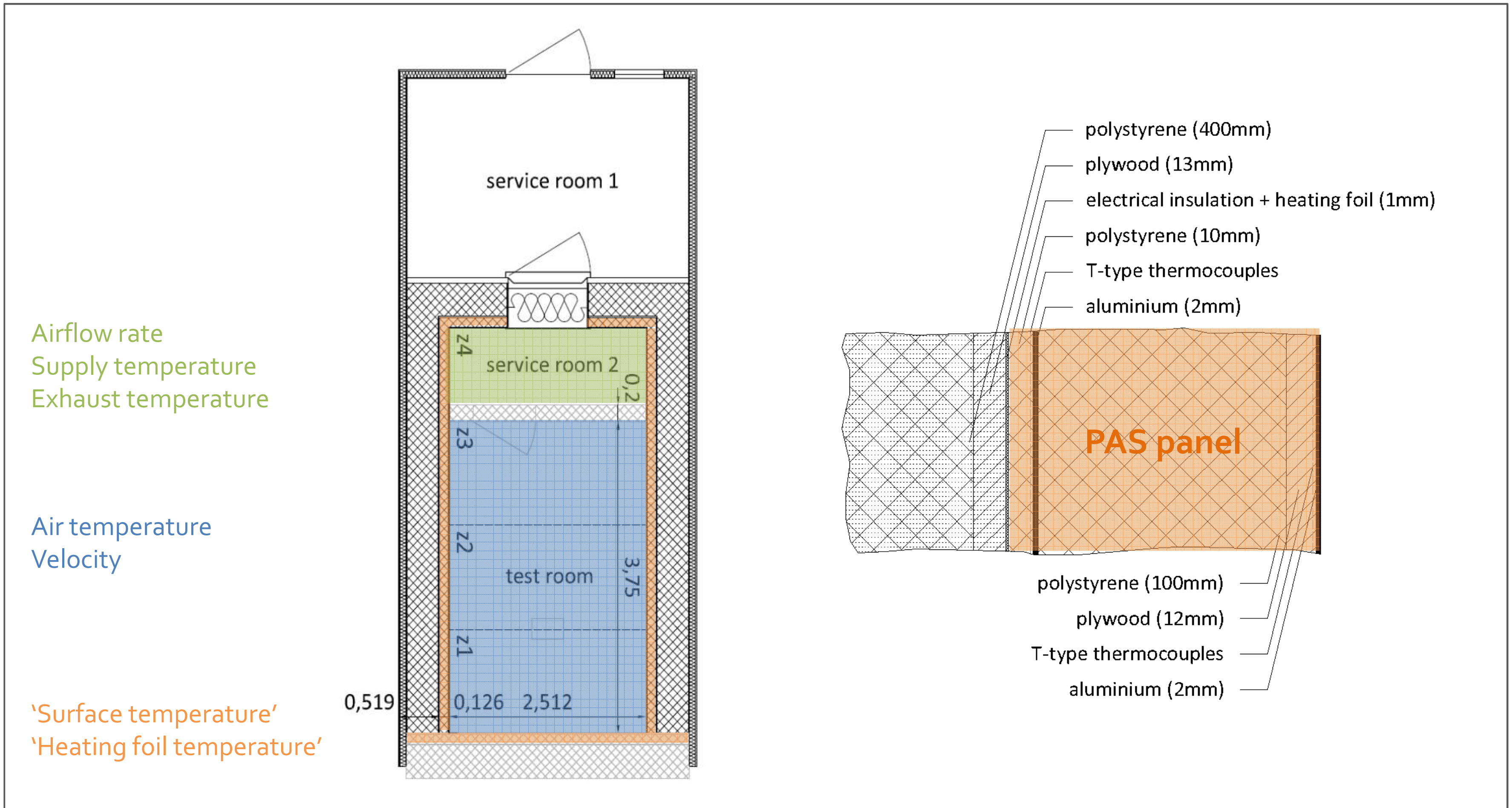
Separation wall (EPS)

Heat source

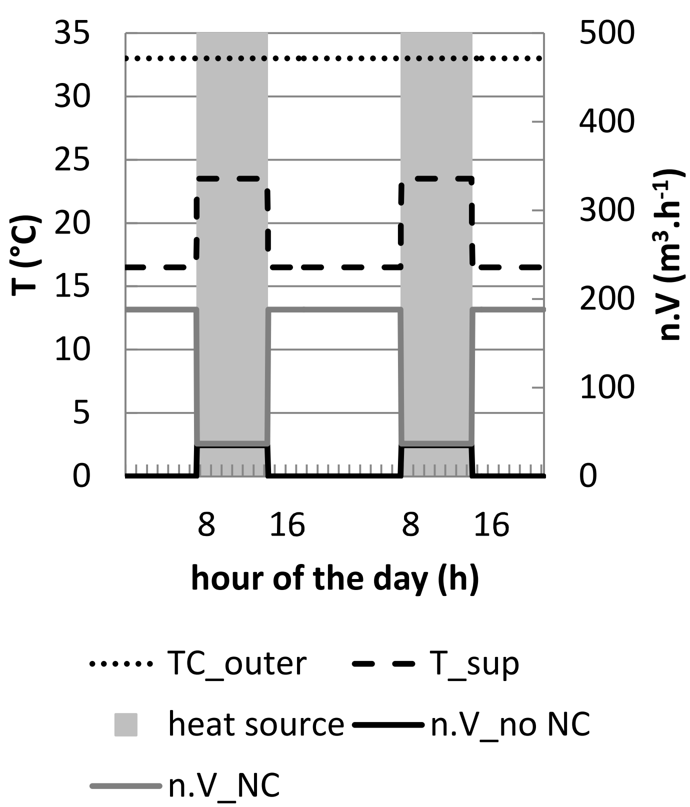
Copy of side walls



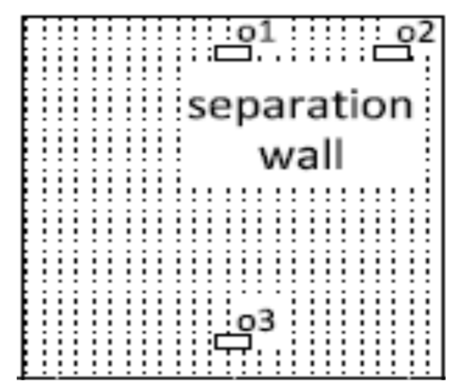
Test equipment



Test procedure



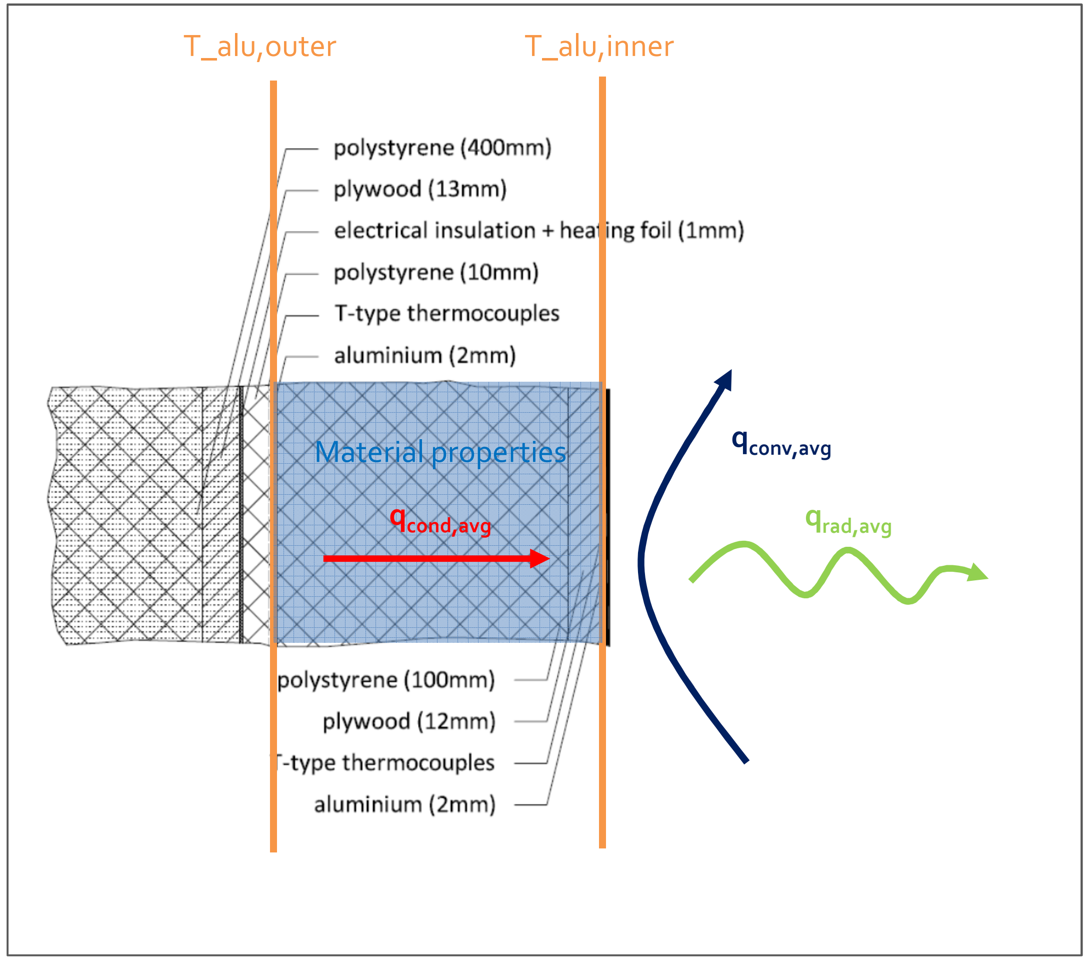
	night cooling?	concrete tiles?	supply at top?
Run 1 (N;C;T)	•	•	•
Run 2 (N;C;t)	•	•	
Run 3 (N;c;T)	•		•
Run 4 (N;c;t)	•		
Run 5 (n;C;T)		•	•
Run 6 (n;C;t)		•	
Run 7 (n;c;T)			•
Run 8 (n;c;t)			



Determining the heat flux more accurately

Previous studies: steady-state conduction, sometimes with correction for radiation

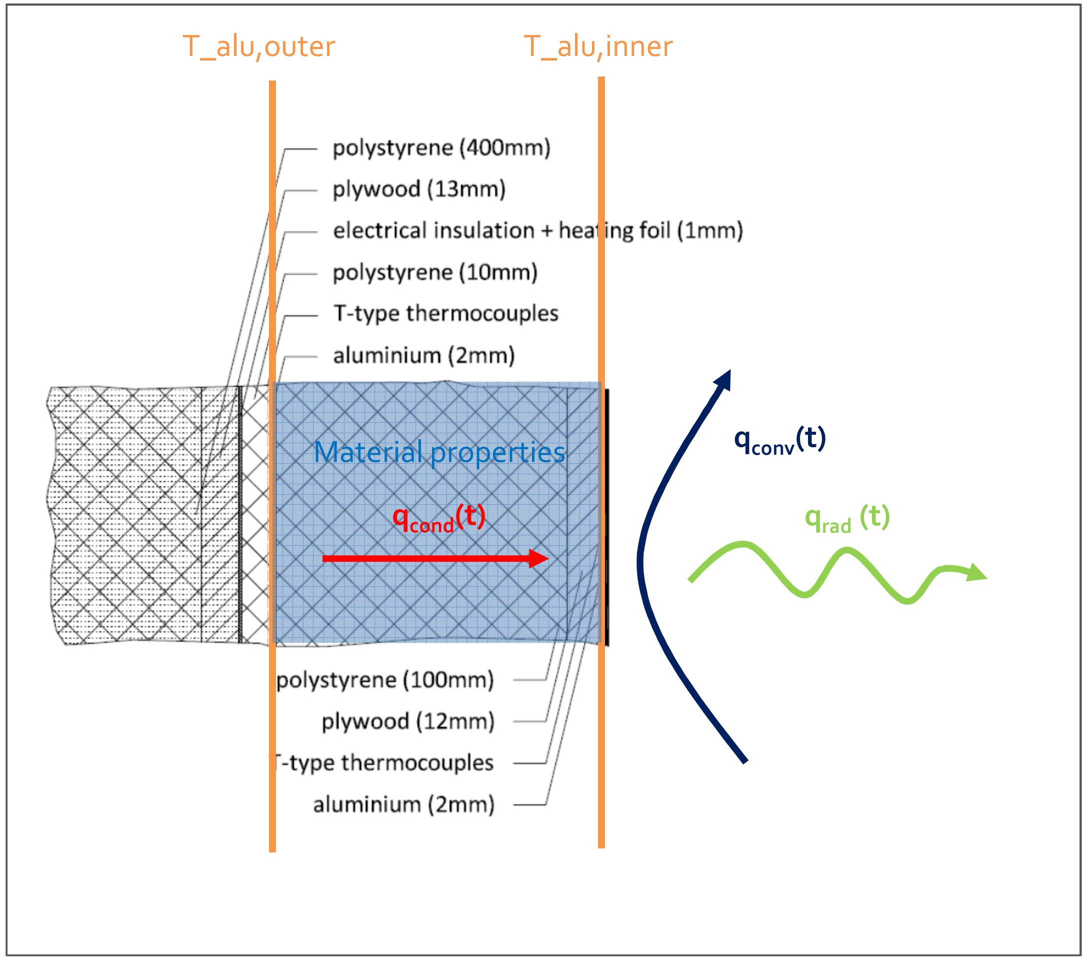
$$q_{conv,avg} = \underbrace{q_{cond,avg}}_{= \Delta T_{avg}.R^{-1}}.\overbrace{(-q_{rad,avg})}^{\sim T_{alu,inner,i,avg}}$$



Determining the heat flux more accurately

This study:
1-D conduction model and view factor-based calculation of radiation

$q_{conv}(t) = q_{cond}(t) - q_{rad}(t)$

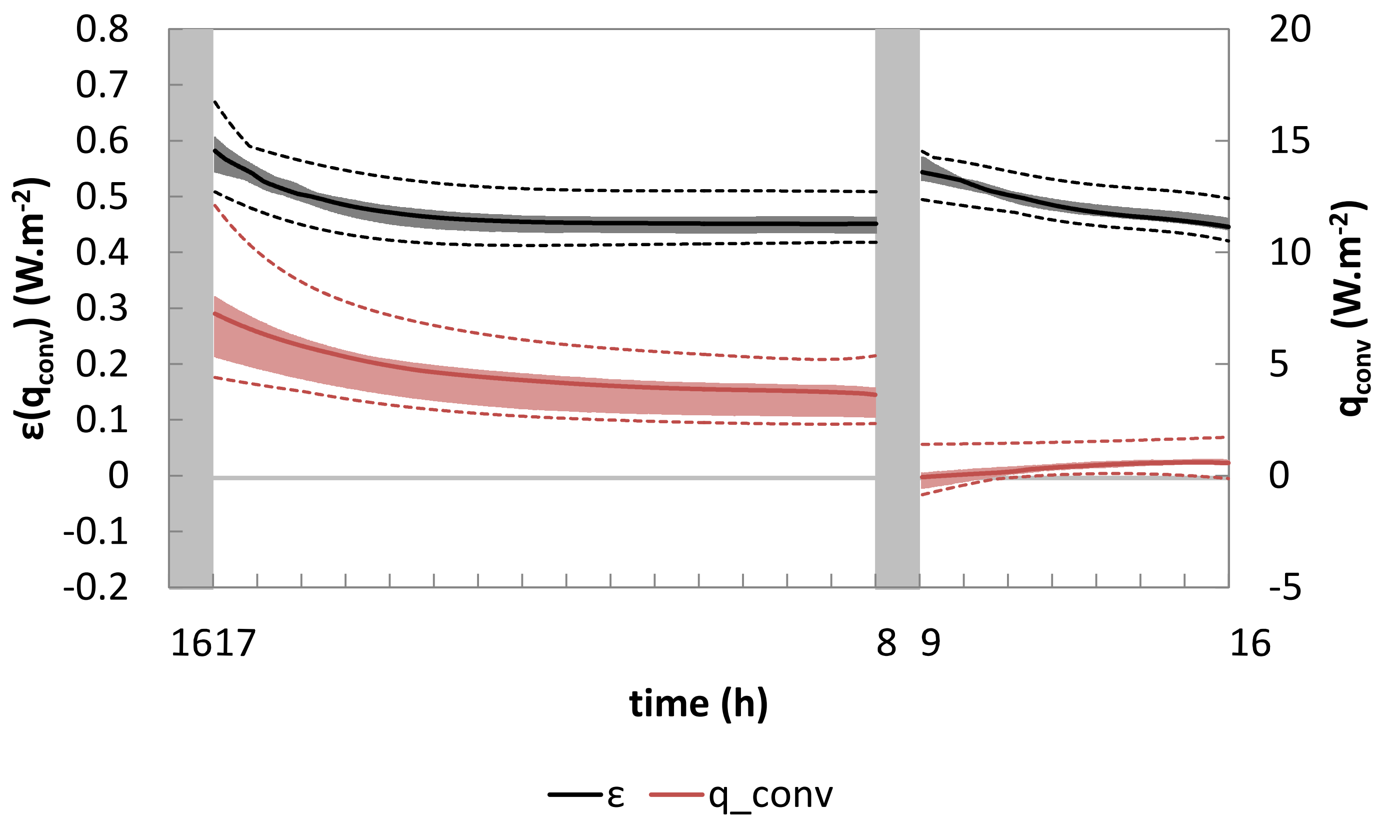


Monte Carlo Analysis to determine uncertainty in convective heat fluxes

Uncertainty due to uncertain inputs in the analysis method (300 data sets)

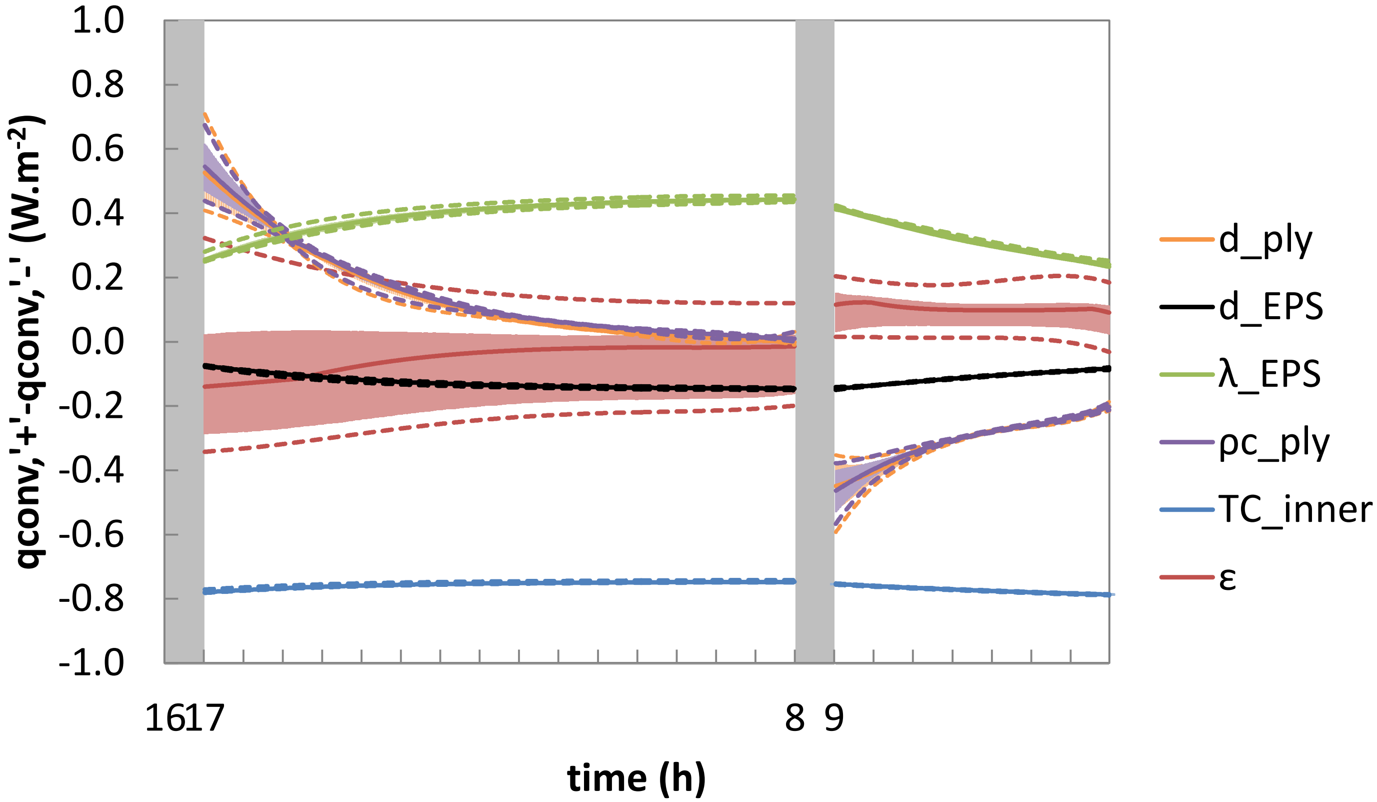
Material properties of PAS layers	**d (m)**	**λ ($W.m^{-2}.K^{-1}$)**	**ρc ($kJ.m^{-3}.K^{-1}$)**
Outer aluminium	0.002 ±10%	230 ±2%	2430 ±5%
Polystyrene	0.100 ±0.002	0.033 ±0.002	26 ±10%
Plywood	0.012 ±5%	0.108 ±0.014	1400 ±5%
Thermocouple readings	**T (K)**		
Outer aluminium	±0.07 (8 readings)		
Inner aluminium	±0.07		
Surface finishing	**ε (-)**		
Interior	0.88 ±0.05		

Monte Carlo Analysis to determine uncertainty in convective heat fluxes



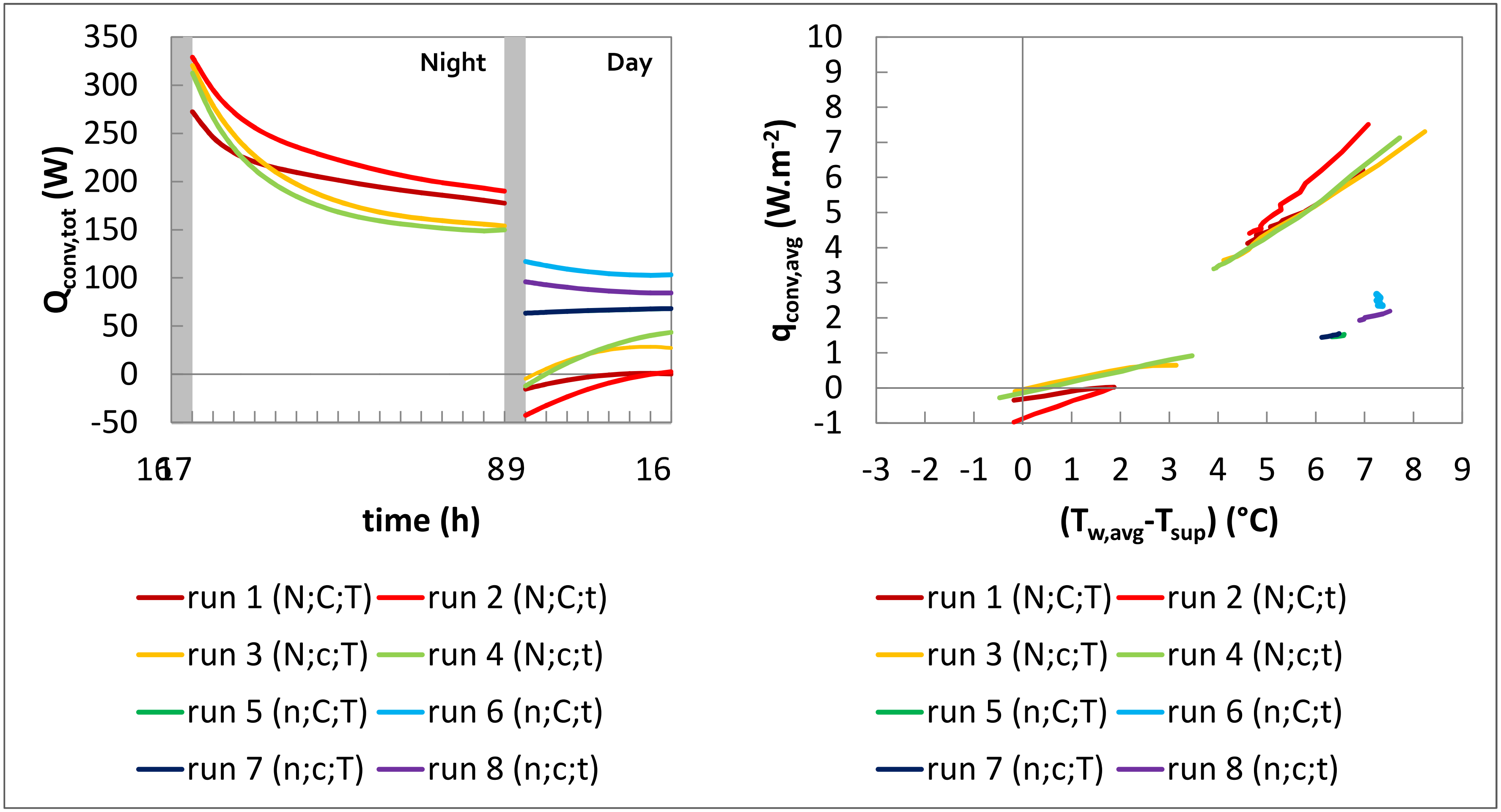
Boxplots of the uncertainties in the convective heat flux at all PAS panels during run 3 (N;c;T)

Sensitivity of convective heat flux to different sources of uncertainty

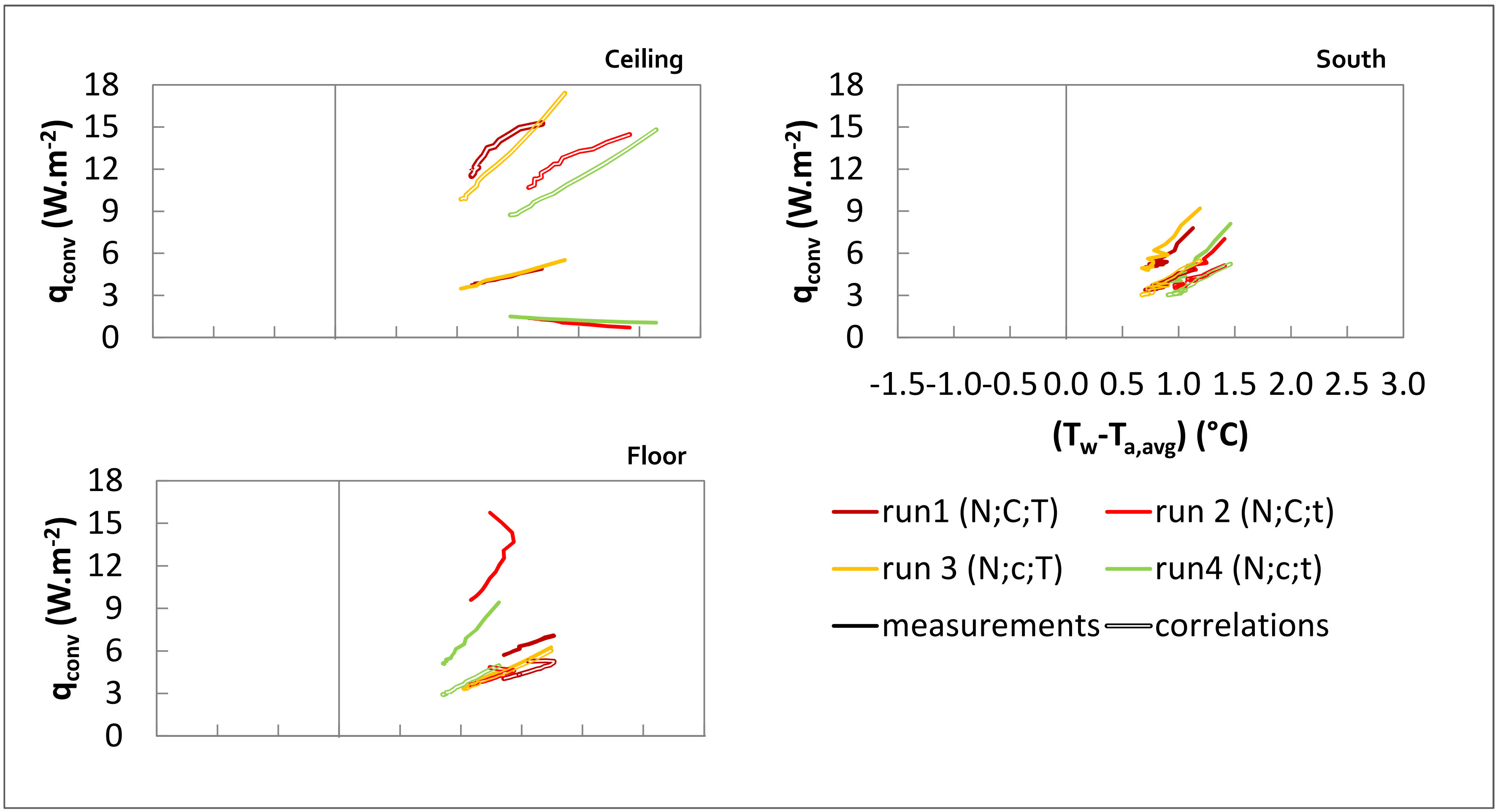


Boxplots of the uncertainties in the convective heat flux at all PAS panels during run 3 (N;c;T)

Impact of air supply/exhaust configuration and thermal mass



Comparison to mixed convection correlations of Beausoleil-Morrison (night)



Need for more accurate approaches to model convective heat transfer

PASLINK cell suited	Well controlled environment Accurate analysis method and error analysis
Impact airflow patterns	Supply/exhaust configuration important in case of high ventilative flow rates and heterogeneously distributed mass
Applicability convection correlations	Unusable when setup and convection regime differ a lot

Article in press:

K. Goethals, M. Delghust, G. Flamant, M. De Paepe, A. Janssens, Experimental investigation of room/system design on mixed convection heat transfer, Energy and Buildings (2012)

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